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PROPOSED NEW PORTABLE AIR COMPRESSOR REGULATION: SUPPLEMENTARY ECONOMIC IMPACT ANALYSIS

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General Electric Company

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PROPOSED NEW PORTABLE AIR COMPRESSOR REGULATION: SUPPLEMENTARY ECONOMIC IMPACT ANALYSIS

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Prepared for the

Office of Noise Abatement and Control
U.S. Environmental Protection Agency
Washington, D.C.

by

General Electric - TEMPO
Center for Advanced Studies
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and
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16. ABSTRACT

This report is an economic impact analysis relating to the potential economic effects (list price increases) of a portable air compressor regulation. This report supplements a previous economic impact analysis performed by A.T. Kearney for EPA/ONAC. GE-TEMPO assessed the cost and economic impacts of several regulatory options under consideration by EPA/ONAC. The scope of the study included the impacts of a useful life, warranty, and test provisions. The study also attempted to establish the differential impacts of the proposed regulation on the industry.

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SECTION I
INTRODUCTION

This document reports the major results of analysis performed by General Electric - TEMPO in support of the rule-making process for portable air compressor noise emission regulations. It supplements the technical support analysis previously done by Bolt, Beranek and Newman (BBN) and A.T. Kearney (ATK).* TEMPO devoted most of its efforts to a supplementary assessment of the cost and economic impacts of several regulatory options under consideration by EPA, including the impacts of the useful life, warranty, and test provisions that lay outside of the scope of the previous analysis. The primary dimensions of the regulatory options are the maximum allowable sound pressure level (76 dBA or 78 dBA) and the time allowed for compliance (12 months, 18 months, or 24 months). Several options being considered are presented in Table I-1.

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* See the following reports for a discussion of the previous analyses:

1. T.W. Freeze, et al, "Portable Air Compressor: The Costs, Benefits and Penalties of Reducing Their Noise," Bolt Beranek and Newman, Report No. 2566c, March 1, 1974. (Referred to hereafter as BBN Report No. 2566c)

2. W. N. Patterson, et al, "Portable Air Compressor Noise," Bolt Beranek and Newman, Report No. 2795a, March 29, 1974.

3. W. N. Patterson, et al, Portable Air Compressor Noise: Diagnosis and Control," Bolt Beranek and Newman, Report No. 2795b, March 29, 1974. (Referred to hereafter as BBN Report No. 2795b)

4. A. T. Kearney, "A Study to Determine the Economic Impact of Noise Emission Standards in the Construction Equipment Industry: Portable Air Compressor Report." (Referred to hereafter as ATK Report.)

Table I-1. Eight regulatory options.

Regulatory Option	Air Flow Capacity (cfm)	Sound Pressure Level (dBA at 7 meters)	Time to Compliance (months)
1	All	76	12
2	All	76	18
3	All	78	18
4	Under 251 Above 250	76 76	18 24
5	Under 251 Above 250	76 76	12 24
6	Under 251 Above 250	76 78	12 18
7	Under 251 Above 250	76 76	12 18
8	Under 251 Above 250	76 78	18 24

Section II presents the major results of the analysis of the impact on portable air compressors list prices that may result from adoption of the alternative regulatory options. The analysis consists primarily of a reworking of the list price/sound level data previously used by BBN to make the list price estimates.

Section III discusses possible differential impacts within the portable air compressor manufacturing industry, both across different types of portable air compressors and across different firms.

Section IV considers possible effects of the useful life, warranty, and test provisions and provides an analytical structure for further analysis that may be conducted when additional data are available. Data limitations prevented quantitative assessments of these provisions.

Section V considers the major economic impacts that may result from the regulations.

TIME TO COMPLIANCE

The options listed in Table I-1 include a consideration of lead times to compliance ranging from 12 months to 24 months. Available data are not sufficient to allow an analysis of the sensitivity of the direct cost of compliance to variations in the lead time (e.g., the difference in costs of achieving compliance in 18 months instead of 24 months). No estimates are given of the cost impact of using a lead time to compliance that is less than that required for orderly adjustment.

The price estimates given in this section should be interpreted as applying to a lead time that allows "orderly adjustments," corresponding to the conditions presumably reflected in the list price/sound level data used for the estimates. The term "orderly adjustment," as used here, implies that sufficient lead time to compliance has been allowed such that there are no serious adverse impacts on manufacturers, suppliers, or users that could be avoided by a reasonable extension of the time to compliance. In other words, there would be no plant shut-downs, serious supplier or user disruptions, or precipitous changes in market shares that result from a severe increase in adjustment costs to a manufacturer that could be substantially reduced if the manufacturer had an additional 12 to 24 months lead time to compliance.

Consideration of the adjustments required for manufacturers to achieve compliance (i.e., the acquisition of such new components as quieter engines, better mufflers, and new acoustical enclosures, in addition to the design modifications required to incorporate these new components into the air compressors) and estimates provided by BBN suggest a lower bound on the time required for orderly adjustment of 12 to 15 months and an upper bound of 24 to 30 months.*

The lead time to compliance written into the final regulation also depends upon a judgment as to when the air compressor manufacturing firms may have begun adjustments toward compliance with the standards

established by EPA. Several alternative start dates are possible, including the following:

- Noise Control Act of 1972.
- Beginning of the BBN investigation, summer 1973.
- The advanced notice of proposed rule making, February 1974.
- The notice of proposed rule making, October 1974.
- The CAGI survey of manufacturers' statements of time required, March 1975.
- The final regulation, summer 1975.

The industry was presumably aware by early 1974 that a standard in the neighborhood of 78 or 76 dBA at 7 meters, or lower, would probably be promulgated. In the docket submission from the legal counsel of the Compressed Air and Gas Institute (CAGI) in December 1974, CAGI explicitly assumed that the 76 dBA standard was that part of the proposed regulation that EPA most wanted to keep.*

Prudent business practice therefore suggests that adjustments should have begun at least 1 year ago, unless the initial actions taken to quiet air compressors are sensitive to the final noise emission target within a range of 2 or 3 dBA. Given that

(a) the common method of quieting is by enclosing the noise generated by the engine without changing the basic design of the air compressor, and

(b) the common form of production used to manufacture portable air compressors is by batch process,

it seems likely that for most compressors the initial actions of quieting should be relatively insensitive to the final noise emission target.

Manufacturers that have been slow to make adjustments toward compliance with standards in the neighborhood of 76 to 78 dBA may incur higher costs of compliance than the averages reflected in the estimated list price increases given here. To the extent that portable air compressor manufacturers have taken action in anticipation of the final regulation, the present position of the industry will be better than that presented by the 1973 list price/sound level data.

ANALYSIS OF LIST PRICE DATA

The possible increases in list prices resulting from the adoption of noise regulations were investigated by two procedures, each using the same list price/sound level data analyzed by BBN. The first procedure was used to estimate the percent increase in prices resulting from quieting so-called "standard" or "unquieted" portable air compressors down to the average sound level of so-called "quieted" compressors (76 or 77 dBA for most engine/capacity classes). The second procedure was used to estimate the price effects of additional quieting down to a sound pressure level of 73 dBA, corresponding to a 76 dBA emission standard and a 3 dBA production tolerance. Each procedure is based on an analysis of "matched pairs," i.e., pairs of portable air compressor models in which the first model of each pair is a standard unquieted version and the second model is a quieted version of the same air compressor.*

First Procedure

The first procedure is a modified form of that used by BBN in their earlier estimates. Average prices and sound pressure levels (SPL) are

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*See Appendix A for a discussion of the reasons for using matched pairs, in contrast to the use of both matched and unmatched pairs of air compressors. Other problems associated with the use of the data are also discussed in Appendix A.

computed, first for the standard unquieted versions of a particular engine and capacity class of air compressors and second for the quieted version of that same class. These average prices and SPL's are computed initially for narrow ranges of air flow capacity (e.g., gas-driven compressors with 250 cfm air flow capacity). Weighted averages are then computed for list prices and SPL's for the three broad classifications of portable air compressors desired by EPA (i.e., gas-driven, diesel-driven with 250 cfm or lower capacity, and diesel-driven with over 250 cfm capacity) using weights based upon AT Kearney estimates of unit sales and average air flow capacities of each class of air compressor. These weights are presented in Table II-1.

The resulting average prices and sound levels are presented in Table II-2. The results are comparable to those calculated by BBN and recorded in Table III of report number 2566c. An edited version of this table is presented here as Table II-3.

The BBN averages are based on larger numbers of air compressors, since the sample used includes standard compressors for which there is no quieted counterpart. Also, the diesel-driven compressors are now divided at 250 cfm in Table II-2 to correspond with the options being considered by EPA, in contrast to the 500 cfm dividing line used earlier and shown in Table II-3. The inclusion of the relatively high priced 325-375 cfm machines in the large diesel-driven compressor class increases the mean price per cfm of the larger machines, compared with the BBN results.

Table II-1. Weights used to obtain average price per cfm and SPL for broad engine/capacity classes.

Engine Type	Air Flow Capacity (cfm)	1972 Unit Sales	Contribution to Total Air Flow Capacity (thousand cfm)	Weight (Relative Contribution to Total Air Flow Capacity)
Gasoline	85	2,157	183.3	.177
	100	925	92.5	.089
	125	1,207	150.9	.146
	160	2,413	386.1	.373
	185	1,207	223.3	.216
		7,909	1,036.1	1.001
Diesel (≤250 cfm)	125	630	78.8	.210
	160	735	117.6	.313
	185	735	136.0	.362
	250	173	43.2	.115
		2,273	375.6	1.000
Diesel (>250 cfm)	365	403	147.1	.104
	600	548	328.8	.234
	750	548	411.1	.292
	900	166	149.4	.106
	1050	118	123.9	.088
	1200	142	170.4	.121
	1600	33	52.8	.038
	1750	14	24.5	.017
		1,972	1,408.0	1.000

Table II-2. 1973 status of portable compressors with respect to noise emissions and price per rated cfm, matched pairs.

	Gasoline Driven		Diesel Driven			
			Below 251 cfm		Above 250 cfm	
	Standard	Quieted	Standard	Quieted	Standard	Quieted
Number of Units	23	23	21	22[a]	24	24
Mean Price Per cfm	$38.83	$42.51	$45.91	$49.51	$44.20	$49.53
Mean SPL at 7m (dBA)	84.1	76.5	84.3	76.6	92.2	78.3
Price Increase, Standard to Quiet:						
Amount	$3.76		$3.60		$5.33	
Percent	9.5		7.8		12.1	

[a]Includes one model that had two quieted versions.

Table II-3. Present status of portable compressors with respect to noise emissions and price per rated cfm, based on BB&N Table III (Report No. 2566c).

	Gasoline Driven		Diesel Driven			
			Below 501 cfm		Above 500 cfm	
	Standard	Quieted	Standard	Quieted	Standard	Quieted
Number of Units	32	26	45	35	32	24
Mean Price Per cfm	$39.23	$43.32	$46.16	$52.11	$43.57	$48.70
Mean SPL at 7m (dBA)	82.8	76.1	86.1	76.4	92.8	78.7
Price Increase, Standard to Quiet:						
Amount	$4.09		$5.95		$5.13	
Percent	10.4		12.9		11.8	

Second Procedure

The price effects of quieting to SPL targets below the average quieted SPL's were computed with the second procedure, which is also based upon an analysis of matched pairs of standard and quieted models.

Only a few matched pairs in the data had SPL's for the quieted version as low as 73dBA, the lowest SPL for which price effects were estimated. Regression analysis was therefore used to obtain estimates of the incremental cost of quieting at the lower SPL's that were not unduly influenced by the quieting and list price behavior of one or two matched pairs.

An incremental cost of quieting (i.e., increased price per dBA of reduced SPL) was first computed for each matched pair. The incremental cost of quieting (ICQ) for each narrow capacity range of compressors (e.g., 750 cfm diesel-driven compressors) was calculated by averaging the ICQ computed from the matched pairs for each one dBA SPL interval below 85 dBA. The ICQ by narrow capacity class was then averaged using the weights given in Table II-1 to yield the average ICQ by one dBA SPL intervals below 85 dBA for each of the three major engine/capacity compressor classes. Figure II-1 presents a scatter diagram of the results for each major class.

Using the data presented in Figure II-1, a simple linear regression* was estimated for each major class of compressors expressing the incremental cost of quieting as a function of sound level. The results are shown graphically in Figure II-1 and numerically in Table II-4.

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* For discussion of regression analysis, see Jan Kmenta, Elements of Econometrics, MacMillan Company (New York, 1971).

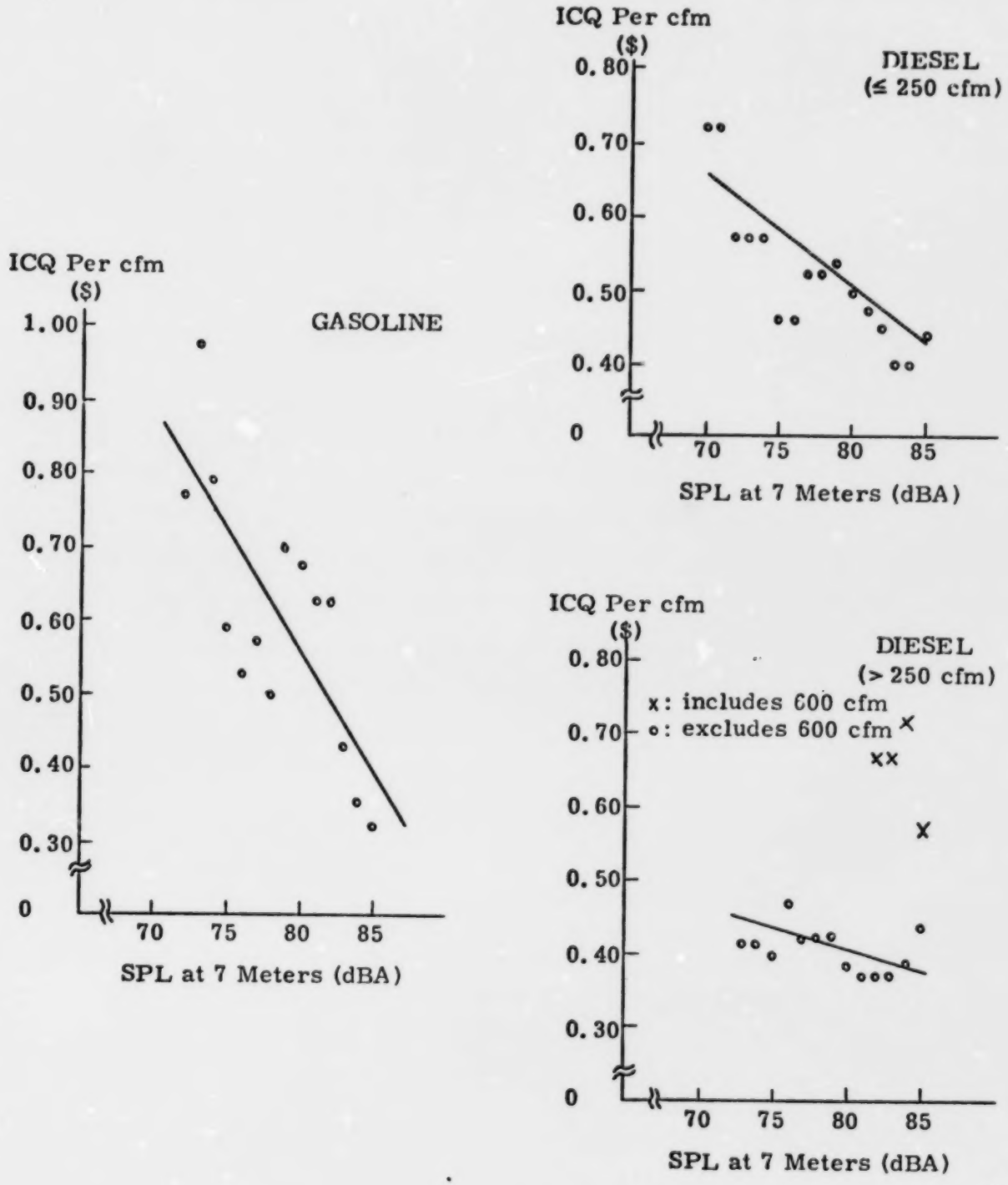

Figure II-1. Scatter diagrams and regression lines used for determination of mid-estimate ICQ's.

Table II-4. Incremental Cost of Quieting Regressions.

Engine/Capacity Class	Equation[a]	R^2
Gasoline	ICQ = \$3.1498 - \$0.0324 SPL (0.0080	0.58
Diesel ($\leq$250 cfm)	ICQ = \$1.6514 - \$0.0143 SPL (0.0037)	0.52
Diesel[b] (>250 cfm)	ICQ = \$0.6100 - \$0.0025 SPL (0.0016)	0.17

a. The term in parenthesis is the standard error of the estimated coefficient of SPL.

b Excludes compressors with 600 cfm airflow capacity.

The regression results imply that the cost of quieting a gasoline-driven compressor from 81 to 80 dBA is $0.58 per cfm; the ICQ increases to $0.79 per cfm for a reduction from 74 to 73 dBA. Corresponding ICQ's for diesel-driven compressors are $0.51 (at 80 dBA) and $0.61 (at 73 dBA) per cfm for models with capacity less than or equal to 250 cfm and $0.40 and $0.41 per cfm, respectively.

The regression for compressors with more than 250 cfm air flow capacity does not include 600 cfm compressors, which had no models in the sound/price data with an SPL below 82 dBA. Inclusion of the 600 cfm would result in a positive coefficient for SPL, implying that the incremental cost of quieting decreases with reductions in sound level.

Even with the exclusion of the 600 cfm compressors, the regression for compressors above 250 cfm has a relatively low R^2 of 0.17,* reflecting in part the paucity of quieting experience for large compressors in the SPL/list price data.

The estimates of ICQ obtained from the equations given in Table II-4 were used to compute "mid estimates" of the price effects of alternative noise emission standards. A second set of ICQ's was calculated for the computation of "worst case estimates" of the price effects. For the gasoline-driven and small** diesel-driven compressors, the "worst case ICQ's" were calculated with a linear function which gave the same ICQ for an 85 dBA sound level, and an SPL coefficient with an absolute value

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* In other words, the regression equation "predicts" only 17 percent of the sample variance of ICQ. See Appendix A for a discussion of factors other than SPL that may influence list prices in the sample.

** 250 cfm or less.

equal to the value given in Table II-4 plus twice the standard error. The "worst case ICQ's" for large* compressors were calculated with a linear function which gave an ICQ at 83.5 dBA of $0.65** and an SPL coefficient with an absolute value equal to the value given in Table II-4 plus twice the standard error. The resulting functions are shown in Figure II-2.

The price effect of quieting a particular engine/capacity class of compressors from one target SPL to another is computed by summing the incremental costs of quieting over the desired range, as estimated by the appropriate function. For example, the "mid-estimate" of the increase in list price resulting from quieting gas-driven compressors from 76.5 dBA to 75 dBA is one-half the ICQ at 76 dBA plus the ICQ at 75 dBA, or $1.06 (i.e., $0.34 plus $0.72).

The procedure is used here only for estimating the price effects of quieting to a range of 76 to 73 dBA. Limited information on the cost of quieting to lower SPL's (e.g., to 70 dBA) can also be obtained, but one should recognize that these estimates are accompanied by possibly severe hazards of extrapolation.

ESTIMATED PRICE EFFECTS

Mid-Estimates

Mid-estimates of anticipated price increases associated with alternative emission targets were calculated combining the sound level/price data on average "standard" and "quieted" compressors given in Table II-2 with the regression results for the incremental cost of quieting given in Table II-4.

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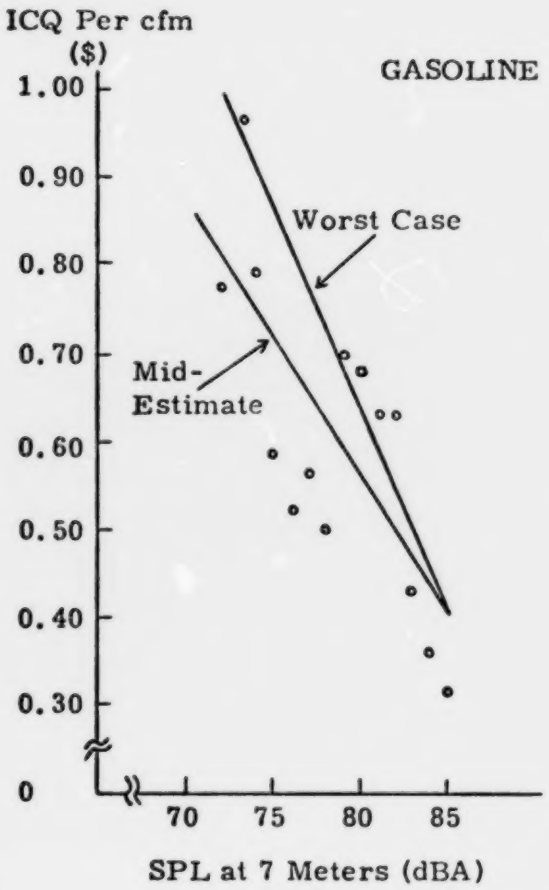
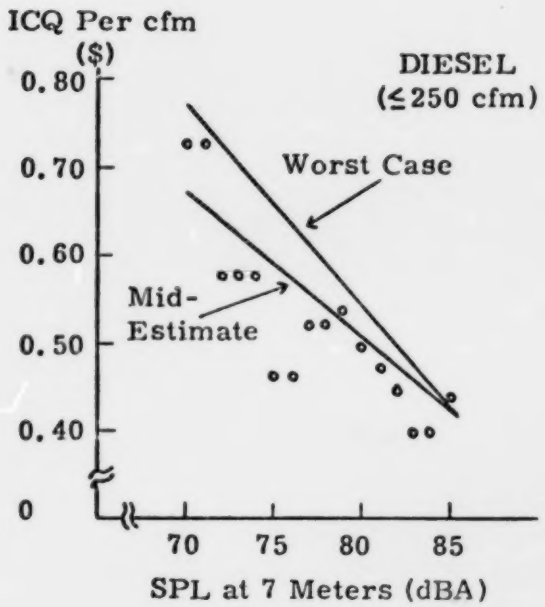
* More than 250 cfm.

** This is the average ICQ for large compressors for SPL's 82 through 85 dBA with 600 cfm.





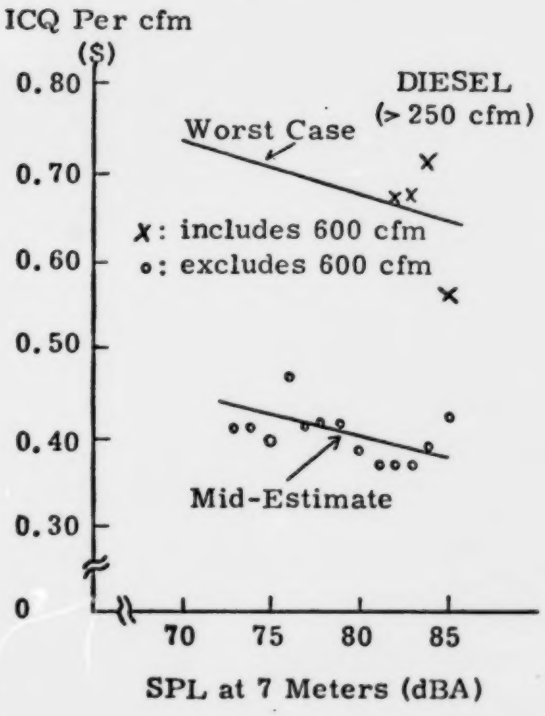


Figure II-2. Scatter diagrams with worst case ICQ lines added.

For compressors with rated capacity above 250 cfm, the data used excludes 600 cfm compressors. Compressors with 600 cfm and 750 cfm rated air flow appear to be relative close performance substitutes for each other, and the data suggest substantially more quieting experience and lower incremental costs of quieting for the 750 cfm machines. Should the cost differential persist, one may anticipate a substantial shift of market shares away from 600 cfm compressors in favor of the 750 cfm machines. The mid-estimates are made under the assumption that 600 cfm machines either adopt the cost-of-quieting characteristics of or are replaced in the market by the 750 cfm machines. (The "worst case estimates," described below, use less optimistic assumptions.)

Estimates were made assuming "not-to-exceed" sound level standards of 78 and 76 dBA (at 7 meters) and production tolerances of both 2 and 3 dBA. These standards and production tolerances result in four production sound level targets:

76 dBA---78 dBA standard with a 2 dBA tolerance
75 dBA---78 dBA standard with a 3 dBA tolerance
74 dBA---76 dBA standard with a 2 dBA tolerance
73 dBA---76 dBA standard with a 3 dBA tolerance

The resulting percent increases in list price are given for standard and quieted models for each major engine/capacity class in Table II-5. The results by major engine/capacity class only are given in Table II-6. For Table II-6, weights of 0.9 for the standard large compressors (i.e., above 250 cfm) and 0.1 for the quieted large compressors were used to obtain the average percent price increase for large compressors. The smaller compressors, gasoline and diesel, were each given weights of 0.8 for the standard models and 0.2 for the quieted versions. The average overall engine/capacity classes are also given in Table II-6, using weights of 0.26, 0.14, and 0.60 for gasoline-driven, small diesel-driven, and large diesel-driven compressors, respectively.*

Table II-5. Estimated price increases from quieting for "standard" and "quieted" versions, by major engine/capacity class: mid-estimates.

	Gasoline-Driven		Diesel-Driven			
			Below 251		Above 250[a]	
	SPL	P/cfm	SPL	P/cfm	SPL	P/cfm
Average "Standard"	84.1 dBA	$38.83	84.3 dBA	$45.91	91.5 dBA	$44.03
Average "Quieted"	76.5	42.51	76.6	49.51	76.1	49.53
Percent above average "standard" price	76	10.4	76	8.6	76	12.6
Percent above average "quieted" price		0.8		0.7		0.1
Percent above average "standard" price	75	12.2	75	9.8	75	13.4
Percent above average "quieted" price		2.5		1.9		0.8
Percent above average "standard" price	74	14.1	74	11.2	74	14.3
Percent above average "quieted" price		4.3		3.1		1.6
Percent above average "standard" price	73	16.2	73	12.5	73	15.2
Percent above average "quieted" price		6.1		4.3		2.4

[a] Excludes 600 cfm compressors.

Table II-6. Estimated price increases, total and by major engine/capacity class: mid-estimates and worst-case estimates.

SPL Target	Percent Increase in Price			
	Gasoline	Diesel Below 251 cfm	Diesel Above 250 cfm	All Models
Mid-Estimate				
76 dBA	8.5%	7.0%	11.4%	10.0%
75	10.3	8.2	12.1	11.1
74	12.1	9.6	13.0	12.3
73	14.2	10.9	13.9	13.6
Worst Case				
75 dBA	10.9	8.4	16.4	13.8
73	15.7	11.4	19.6	17.4

For the 76 dBA target, the estimated price increase ranges from 8.6 percent for standard small diesels to 12.6 percent for standard large diesels, with an average of 10.0 percent over all models. For the 73 dBA target, the estimated price increase ranges from 10.9 percent for small diesels to 14.2 percent for gasoline-driven compressors, with an average of 13.6 percent over all models.

Worst-case Estimates

An additional set of estimates, the "worst-case estimates," was computed to test the sensitivity of the results to the use of less optimistic assumptions. The most important change was to assume that 600 cfm compressors retain their share of the market while remaining relatively expensive to quiet. In addition, the higher estimates of the incremental cost of quieting described earlier were used to determine the cost of quieting from the average SPL of "quieted" compressors to the desired targets. Production sound level targets of 75 and 73 dBA were calculated, corresponding to 78 and 76 dBA not-to-exceed standards with a 3 dBA production tolerance.

The results are presented in Tables II-6 and II-7. The major impact of the less optimistic assumptions is on the price impacts of the large diesels. The average SPL's of quieted gasoline and small diesel compressors are already close to the 75 dBA targets (76.5 and 76.6 dBA, respectively, as shown in Table II-2), so that the estimated price effects are relatively insensitive to assumptions about the incremental costs of quieting. The inclusion of the 600 cfm compressors however, results in an increase of approximately 70 percent in the incremental cost of quieting large compressors for SPL's below 80 dBA and increases the average SPL of "quieted" large compressors from 76.1 to 78.7 dBA, thus increasing the amount of quieting required to achieve any given production target.

Table II-7. Estimated price increases from quieting for "standard" and "quieted" versions, by major engine/capacity class: worst case estimates.

	Gasoline Driven		Diesel Driven			
			Below 251		Above 251[a]	
	SPL	P/cfm	SPL	P/cfm	SPL	P/cfm
Average "standard"	84.1 dBA	$38.83	84.3 dBA	$45.91	92.8 dBA	$43.57
Average "quieted"	76.5	42.51	76.6	49.51	78.7	48.70
Percent above average "standard" price	75	12.8%	75	10.0%	75	17.6%
Percent above average "quieted" price		3.1		2.0		5.3
Percent above average "standard" price	73	17.7	73	13.0	73	20.9
Percent above average "quieted" price		7.5		4.8		8.2

[a] Includes 600 cfm machines.

II-19

The large diesels also carry the greatest market share (in value terms), with a resulting weight of 0.60 (of a total of 1.00) in the average price increase for all models. Thus the worst-case estimate of 19.6 percent for large diesels (compared to the mid-estimate of 13.9 percent) for the 73 dBA target translates into an average increase over all models of 17.4 percent (compared to the mid-estimate of 13.6 percent).

COMPARISON WITH EARLIER RESULTS

Table II-8 presents some of the results of the earlier BBN and ATK analysis for comparison with the current TEMPO results. The estimated price increases are those associated with quieting to 74 dBA, except for the Kearney/CAGI estimate for compressors over 500 cfm. (Note also that the division of large and small compressors was 500 cfm, compared with the present division being considered by EPA of 250 cfm.)

The estimates presented from the earlier analysis represent upper and lower bounds of the estimated price increases generated by BBN and ATK. With the exception of the estimates for compressors above 250 cfm, which are less than those of the earlier analysis, the TEMPO estimates fall within the upper and lower bounds of the earlier analysis. The TEMPO estimates also are based upon procedures that avoid important problems found in the BBN methodology (see Appendix A) and on a sample size considerably larger than the 19 models used for the Kearney/CAGI estimates.

CONCLUSIONS

To the extent that the 1973 SPL/price data reflect the increases in prices associated with an orderly quieting program, one might anticipate an average price increase between 10 and 15 percent in response to the

Table II-8. Comparative Results: Estimated price increase associated with quieting to 74 dBA.

	GASOLINE	DIESEL	
	All (Below 251 cfm)	Below 501 cfm	Above 500 cfm
BBN LIST PRICE	16.2%	18.4%	16.9%
KEARNEY/CAGI Incremental Margin	8.2	6.0	15.3 (76 dBA)
TEMPO			
	All	Below 251 cfm	Above 250 cfm
Mid-estimate	12.1%	9.6%	12.3%
Worst-case estimate	13.3	9.9	15.6

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regulatory options considered. Important qualifications accompany this assessment.

In particular, there are significant differences between the list prices and actual transaction prices of portable air compressors. Discounts from list prices up to 40 percent are reportedly common. Ideally, the estimates should be based on actual transaction prices.

Also, the sound level and price data are two years old. Portable air compressor prices have increased substantially during this period, and it is likely that the price behavior of quieted and standard models have not always coincided. In addition, the industry has two years of quieting experience not reflected in the data.

It is not possible to assess at this time the effect that improved data would have on these estimates. There is no reason to believe, however, that better data would result in a significant increase in the estimated price impacts given in this section.

SECTION III

DIFFERENTIAL IMPACTS ON THE PORTABLE AIR COMPRESSION INDUSTRY

INTRODUCTION

This section presents a review of data available to us from a number of sources through EPA, with a focus on possible differential impacts of the noise emission standards on the air compressor industry. Data have first been organized into air flow capacity profiles which give the average SPL's and prices per cfm for each of the three broad engine type-capacity classes of equipment. Next, a set of firm profiles are given. Finally, the summary results of an EPA survey of the industry's estimates of the time required for compliance are presented.

Most of the capacity, SPL, and list price data are from 1973 SPL/list price data used earlier, with some additional information on specific models and manufacturers coming from a recent EPA survey of the industry. Each manufacturer produces air compressors not included in the SPL/price data, so that the firm profiles present an incomplete picture of the industry situation.

AIR FLOW CAPACITY PROFILES

Tables III-1, III-2, and III-3 present air flow capacity profiles for gasoline-driven air compressors, diesel-driven models with 250 cfm or less rated capacity and diesel-driven models with more than 250 cfm of rated capacity, respectively. Within each broad engine type-capacity class, the average SPL's and prices per cfm are given for narrow capacity classes for standard and quieted models. Weighted averages, with weights based on market shares, are given at the bottom of each table.

Table III-1. Average sound levels and price per cfm for gasoline driven air compressors by capacity.

Air Flow Capacity	"Standard"		"Quieted"	
cfm	SPL	P/cfm	SPL	P/cfm
85 (0.177)[a]	80.4 dBA	$45.31	75.6 dBA	$49.60
100 (0.089)	87.5	39.70	75.8	44.55
125 - 130 (0.146)	86.4	42.57	77.2	43.77
150 - 160 (0.373)	83.8	35.52	76.3	40.34
175 - 250 (0.216)	84.1	36.18	76.9	38.56
Weighted Average	84.1 dBA	$38.83	76.5 dBA	$42.51

[a] Numbers in parentheses represent weights attached to each capacity class based on market shares, as given in Table II-1.

Table III-2. Average sound levels and price per cfm for small diesel driven air compressors by capacity.

Air Flow Capacity	"Standard"		"Quieted"	
cfm	SPL	P/cfm	SPL	P/cfm
85 - 130 (0.210)[a]	81.0 dBA	$52.83	74.5 dBA	$56.14
150 - 160 (0.313)	84.8	44.00	76.0	50.66
170 - 190 (0.362)	86.1	42.77	76.7	49.54
250 (0.115)	83.8	54.10	74.8	61.04
Weighted Average	84.3 dBA	$45.91	76.6 dBA	$49.51

[a] Numbers in parentheses represent weights attached to each capacity class based on market shares, as given in Table II-1.

Table III-3. Average sound levels and price per cfm for large diesel driven air compressors by capacity.

Air Flow Capacity	"Standard"		"Quieted"	
cfm	SPL	P/cfm	SPL	P/cfm
325 - 375 (0.104)[a]	87.9 dBA	$49.56	76.2 dBA	$56.64
600 (0.234)	93.8	42.05	84.4	49.61
750 (0.292)	90.9	42.40	75.2	49.50
800, 850 (0.106)	90.5	43.32	75.0	47.13
900 (0.088)	95.2	45.28	78.4	50.72
1050 (0.121)	92.2	43.81	80.6	48.24
1200 (0.038)	95.0	45.89	76.8	50.08
1600, 2000 (0.017)	95.2	41.79	77.4	46.29
Weighted Average	92.2 dBA	$44.20	78.3 dBA	$49.77

[a]Numbers in parentheses represent weights attached to each capacity class based on market shares, as given in Table II-1.

These profiles (based on 1973 data) suggest that the smaller compressors (with capacities of 250 cfm or less) are in relatively good positions with respect to noise emission standards being considered. The average sound level of quieted machines is more than 77 dBA in for only one engine/capacity class, and is below 76 dBA for several classes.

The position of larger compressors (with capacities more than 250 cfm) is less favorable. The average sound level of two engine/capacity classes (600 and 1050 cfm) is more than 80 dBA and lies between 77 and 80 dBA for two additional classes. If these conditions continue, one might anticipate some shifting of market shares away from the 600 and 1050 cfm machines in favor of the 750 and 1200 cfm machines.

FIRM PROFILES

The following tables present firm profiles based on sound pressure level and other data. For each manufacturer, the proportion of the models in each of four SPL categories are given. Table III-4 presents the data for compressors with rated capacities of 250 cfm or less. Table III-5 presents the data for compressors with rated capacities of more than 250 cfm.

As one might anticipate from the preceding discussion, most manufacturers appear to have relatively quiet models available for compressors with 250 cfm or smaller rated capacities. There are exceptions, however. Manufacturer number 6, in particular, had versions with SPL's below 80 dBA available for only 17 percent of the engine/capacity model lines reported in the 1973 data.

The position with respect to the larger compressors is less favorable. None of the models reported for manufacturers 2 and 6 is below 80 dBA, and none of those reported for manufacturer 7 is below 85 dBA.

Table III-4. Percent of models by SPL level for air compressors with rated air flow capacity ≤250 cfm.

Manufacturer	SPL of Quietest Model of Specific Rated Capacity (dBA)			
	<76	76 - 80	81 - 85	>85
1	83	—	17	—
2	—	75	25	—
3	14	71	14	—
4	75	25	—	—
5	100	—	—	—
6	17	—	33	50
7	20	60	20	—
8	100	—	—	—
9	83	—	17	—
10	14	71	—	14
11	43	14	29	14
12	42	25	25	8

Table III-5. Percent of models by SPL level for air compressors with rated air flow capacity >250 cfm.

Manufacturer	SPL of Quietest Model of Specific Rated Capacity (dBA)			
	<76	76 - 80	81 - 85	>85
1	17	17	33	33
2	—	—	33	66
3	—	100	—	—
4	50	—	50	—
5	20	—	80	—
6	—	—	100	—
7	—	—	—	100
8	None Reported			
9	12	50	25	12
10	20	—	60	20
11	—	33	—	66
12	28	57	—	44

INDUSTRY ESTIMATES OF TIME REQUIRED FOR COMPLIANCE

In the spring of 1975, EPA conducted a survey of the portable air compressor industry to obtain the estimates of individual manufacturers of the time required to come into compliance with 76 dBA and 78 dBA standards. The resulting data have been organized and presented in Table III-6 according to two different formats. The first format presents the number of manufacturers (out of a total of 11 reporting) that would have less than 20 percent, from 21 to 40 percent, and more than 40 percent of their models non-complying for each of the regulatory options, assuming that their models did not come into compliance until the times reported in the survey. The second format presents the number and percent of non-complying models, by major capacity class, that would be non-complying under each regulatory options.

The major finding from the table is that, according to individual manufacturer estimates, a major portion of the industry would be unable to achieve compliance with any regulation requiring the attainment of a 76 dBA or 78 dBA standard within 12 months.

Table III-6. Impacts of Different Regulatory Options

Regulatory Option	Air Flow Capacity (cfm)	Sound Pressure Level (dBA at 7 meters)	Time to Compliance (months)	Number of Manufacturers with less than 20% Non-complying Models	Number of Manufacturers with 21 - 40% Non-complying Models	Number of Manufacturers with more than 40% Non-Complying Models	Non-complying Models					
							Total		≤ 250cfm		> 250cfm	
							No.	Percent	No.	Percent	No.	Percent
1	All	76	12	0	2	9	87	74	36	61	51	88
2	All	76	18	3	3	5	53	45	16	27	37	64
3	All	78	18	5	3	3	36	31	2	3	34	57
4	Under 251 Above 250	76 76	18 24	6	3	2	31	26	16	27	15	26
5	Under 251 Above 250	76 76	12 24	4	1	6	49	42	34	58	15	26
6	Under 251 Above 250	76 78	12 18	2	2	7	68	58	35	60	33	56
7	Under 251 Above 250	76 76	12 18	1	2	8	73	62	36	61	37	64
8	Under 251 Above 250	76 78	18 24	8	2	1	14	12	8	14	6	10

SECTION IV

"USEFUL LIFE" AND WARRANTY PROVISIONS AND TESTING

INTRODUCTION

The "useful life"* provision of the proposed regulation states that the air compressors shall be designed so that if properly maintained, operated and repaired, they will not produce average sound levels in excess of 76 dBA for the first year after the sale and no more than 79 dBA up until the fifth year.** The warranty provision requires the manufacturer to warrant to the first and each subsequent retail purchaser that the air compressors were designed, built, and equipped so as to conform with the regulation at the time of sale. The warranty covers the equipment for one year after the first retail sale.

The purpose of these provisions is to prevent unreasonably fast degradation (due to defects or otherwise) of the noise control capability of air compressors which would adversely affect the public health and welfare. It is recognized, that a certain degradation in the noise control capability of the equipment is inevitable unless certain parts are replaced and/or the equipment is overhauled periodically. The intent of the "useful life" provision is to induce the manufactureres to incorporate into the equipment noise control devices and design elements which will insure an acceptably slow acoustical degradation (this concept is also

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* The term "useful life" was used originally when the provision applied to the entire life of the equipment. EPA has since shortened its time requirement for the provision but the term still remains.

** Some alternatives now contemplated provide for 78 dBA for the first year and 81 dBA up until the fifth year for portable air compressors with more than 250 cfm capacity.

sometimes referred to as "graceful degradation"). The warranty provision gives the manufacturer an incentive to avoid defects by shifting to him the burden of repairing or replacement of any faulty equipment or parts.

The "useful life" and warranty provisions did not receive any substantial attention by previous contractors. As a result of that and of the limitations in time and funds of this contract the data required for estimating the costs of these provisions are very limited. This fact has prevented us from engaging in a detailed costing of the provisions.

However, in what follows we will develop a framework within which the concepts of the "useful life" and the warranty can be analyzed. In addition, we will use assumptions based on whatever fragmentary data we have in order to demonstrate how this framework can work with adequate data. The examples which will be generated will, among other things, indicate the range of calculated risks which EPA and the portable air compressor manufacturers may be taking in making decisions with respect to the "useful life" and the warranty with inadequate data. These examples also give EPA a better picture of policy trade-offs.

IMPLICATIONS FOR MANUFACTURERS

As a first step toward the calculation of costs imposed by the "useful life" and warranty provisions we will focus on the implications of these provisions for the manufacturers of portable air compressors.

We start with the assumption that portable air compressor manufacturers will respond to the "useful life" provision by attempting to adjust their design and production processes in such a way as to avoid first triggering and then failing any selective enforcement audit (SEA) tests and to avoid product recalls, since these eventualities are very costly. This implies that they will attempt to achieve the acceptable

quality level (AQL) concomitant with the SEA procedure and make sure that a sufficiently high percentage of machines comply with the noise level maintenance provision so that a recall is unjustified.

Given the assumption above, manufacturers will take appropriate actions prior to the point of sale. These actions will generally involve testing and engineering analysis to make sure that the above conditions are met. Manufacturers may engage in some redesign of the product and the production process if the above conditions are not currently met. A manufacturer may achieve his compliance targets by setting a low enough noise emission target to allow for engineering tolerances and noise performance degradation or by tightening the existing engineering tolerances, or both. At this stage, the manufacturer must take into account the noise characteristics of parts and materials he buys from suppliers and of those he manufactures himself, as well as the quality of his own workmanship.

In addition to the above actions, the manufacturers will be required to instruct the users of the equipment on proper maintenance procedures for compliance with the regulation. As part of the maintenance schedule, the manufacturer will specify the frequency with which certain parts may have to be replaced to maintain the noise performance of the equipment prescribed by the regulation.

Some aspects of the warranty provision need to be clarified. It has often been asserted that the warranty in question is a "defects" warranty for defects in materials, parts or workmanship existing at the time of sale. However, both the wording of Section 6(d)(1) of the Noise Control Act (which concerns the warranty) and the transcripts of congressional hearings and floor debates prior to the passage of the Act tend to give the work "defect" a broad interpretation that covers anything which was under the manufacturer's control. The implication of this is that if the user operates the equipment under normal conditions and maintains

it according to manufacturer's instructions, and still the equipment fails to meet the standard at any time during the "useful life" this may be prima facie evidence that there was a defect in materials, parts or workmanship at the time of sale which led to the violation of the standard After the "useful life" no defect can be proved because the equipment has performed according to the regulation.* For this reason, and in order to be consistent with the "useful life" provision, the warranty claim period should not perhaps exceed the "useful life". It may, however, be shorter in accordance with general industry warranty practices. In any event, a minimum 3-month warranty could be required to at least cover obvious defects in materials and workmanship.**

Although the "useful life" and warranty provisions are closely related, there are some important distinctions between them. The "useful life" provision establishes a responsibility of the manufacturer to EPA, while the warranty provision establishes a responsibility to the user. Thus, the warranty provision provides a mechanism for state and local authorities to exert pressure through the user on the manufacturer to repair or replace non-complying equipment.

Another distinction between the two provisions is that, unlike the "useful life" provision, the warranty provision covers all air compressors individually and makes no allowance for non-complying equipment. This may induce the manufacturer to reduce any percentage of non-complying equipment to a level lower than if the warranty provision did not exist and the "useful life" provision were the only one applicable.

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* This assertion does not take into account the intensity of usage of the equipment. For example the equipment may have not been used or may have been used lightly over the "useful life" thus not allowing the defects to manifest themselves. The only way to cover this case is to base the "useful life" provision on hours of operation in addition to or instead of calendar time after the sale.

** According to docket item #36 (Gimer for CAGI), basic design, material and workmanship defects generally become apparent within three months.

Moreover, in response to the warranty provision, the manufacturer will perhaps attempt to prevent defects in the parts he buys from suppliers and establish stricter quality controls for work done in his premises. For parts which need periodic replacement he will instruct the user on the frequency of such replacement, taking responsibility only for the original part. Those parts which were purchased from suppliers would be expected to have supplier warranties.

COSTS IMPOSED BY THE "USEFUL LIFE" AND WARRANTY PROVISIONS

From the preceding discussion it is evident that the manufacturers will bear certain costs in their efforts to comply with the "useful life" and warranty provisions. These costs were not taken into account during the original cost studies by BBN and A. T. Kearney. The latter states:

> "...responsibility for noise levels generated after (the portable air compressor has been) in operation would involve costs and other considerations not provided for in this assessment."

An estimate of what additional costs are imposed by the above provisions can be obtained by looking at the steps the manufacturers will have to take to comply with them. At the design and production phase these steps may include costs of diagnostic testing or monitoring to determine the noise level degradation characteristics of the equipment and hence the extent to which current models do not comply with the provisions above. Other costs will apply at the design and production stages, to the extent changes in the design or production processes are necessitated by the provisions. These costs may generally involve new or better parts and materials, better workmanship, more accurate production techniques, and tighter quality control procedures. In general, it may be difficult to

distinguish design and production costs related to the "useful life" and warranty provisions from similar costs related to complying with the noise limit. The cost of issuing additional instructions to the user is also part of the cost of the "useful life" and warranty provisions.

An important point is that it is not possible for a manufacturer to design an air compressor which meets these provisions with any degree of certainty unless he knows what the acoustical degradation characteristics of the equipment are. In the absence of reliable information concerning these characteristics the manufacturers are taking risks.

In addition to the above costs which are generally pre-sale costs manufacturers will sustain after-sale costs as well. These generally include such costs as repair or replacement of non-complying equipment, maintaining a field service, etc.

Users will also sustain some costs as a result of the provisions in question. These are generally costs to keep the equipment in compliance with the regulation and the provisions of the warranty such as the proper maintenance and replacement of parts. These costs, however, are not directly imposed by the EPA regulation, but may be considered costs of compliance with state and local regulations.

ESTIMATION OF COSTS

There are many different methods for estimating costs. One is to obtain engineering cost estimates for design and production costs, i.e., to list in detail the various steps required to comply with the "useful life" and warranty provisions and then estimate the costs involved in each one of them broken down into R&D, capital, materials and labor costs. A simple addition of all costs by category would result in total costs. An example of a worksheet for the estimation of parts costs to users is given in Figure IV-1.

Figure IV-1. Worksheet for Useful Life Costs

Useful Life (years) _____ (A)

	B	C	D	E	F	
Component	Average Life (Years)	Number Required Over Useful Life $\left(\frac{A}{B} - 1\right)^*$	Number Used In A/C	Total Number Required Over Useful Life (C x D)	Price ($)	Total Cost For This Component (E x F) ($)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
					Total Cost	

*If $\frac{A}{B}$ is not an integer, round to the nearest higher integer.

There are several problems with this approach. One, for example, is that design and production costs due to the "useful life" and warranty provisions are in many cases joint costs with other design and production costs and, therefore, not separately identifiable. The basic problem, however, is lack of data. To begin with, there are only scant data on the acoustical degradation characteristics of air compressors and their parts. Even if adequate degradation data were available, there is lack of some essential cost data. For example, there are no data available to us on what it costs to reduce engineering tolerances in the manufacturing of some parts. Limited data exist on after-sale costs. For example, we know that defective air compressors are generally between 0.5 and 3 percent of the equipment sold, but costs per defect are not available to us. One manufacturer reported that current costs of warranty repairs average to 4.6 percent of list prices.

After surveying the difficulties connected with the above cost estimating procedure we concluded that we could not use it, primarily due to lack of data. Limited cost estimates were derived on the basis of changes in production costs associated with different noise level production targets and engineering tolerances. The method described below also provides an analytical framework which is more generally applicable.

A PROCEDURE FOR ESTIMATING THE DESIGN AND PRODUCTION COSTS OF THE "USEFUL LIFE" AND WARRANTY PROVISIONS

It is first assumed that portable air compressor manufacturers will set a target for equipment noise level which is below the noise limit of the regulation. This target noise level will depend on the engineering tolerances and on allowances for degradation when the equipment goes into use. In fact, the noise level of the equipment at the point of sale

will vary according to a probability distribution.* Figure IV-2 portrays such a distribution. The parameters of this distribution (mean and standard deviation) can be expected to be such that the percentage of non-complying equipment at the point of sale does not exceed the AQL implied by the Selective Enforcement Audit (SEA) procedure described in the regulation (currently 10 percent), and the percentage of non-complying equipment over the "useful life" does not exceed a certain level. It is not clear at this point what this level is, but it seems reasonable that manufacturers would select such a level as another target for their production process. Note that this level may lead to a tighter constraint than the AQL constraint due to normal degradation, in which case the significance of the SEA test diminishes. The manufacturers may either tighten their engineering tolerances or lower their noise level target in order to achieve a certain compliance goal for equipment in use over the "useful life" period.

The amount of acoustical degradation of portable air compressors over any specified time period will also vary according to a probability distribution. This distribution, overlaid on the production distribution mentioned above, will yield a combined distribution of noise levels at the end of the specified period, such as the one portrayed on the right in Figure IV-2. (The mathematical theory of combining probability distributions is given in Appendix B.) Conceivably one could generate a distribution for a number of different time periods. In general, successive distributions will correspond to increasing average noise levels (or acoustical degradation levels) and standard deviations.

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* We may assume that this distribution includes the error distribution of the sound measuring instrument. The error distribution is generally normal with a mean of zero dBA. The standard deviation is approximately 0.5 dBA giving a range of error of $\pm$ 1.5 dBA.

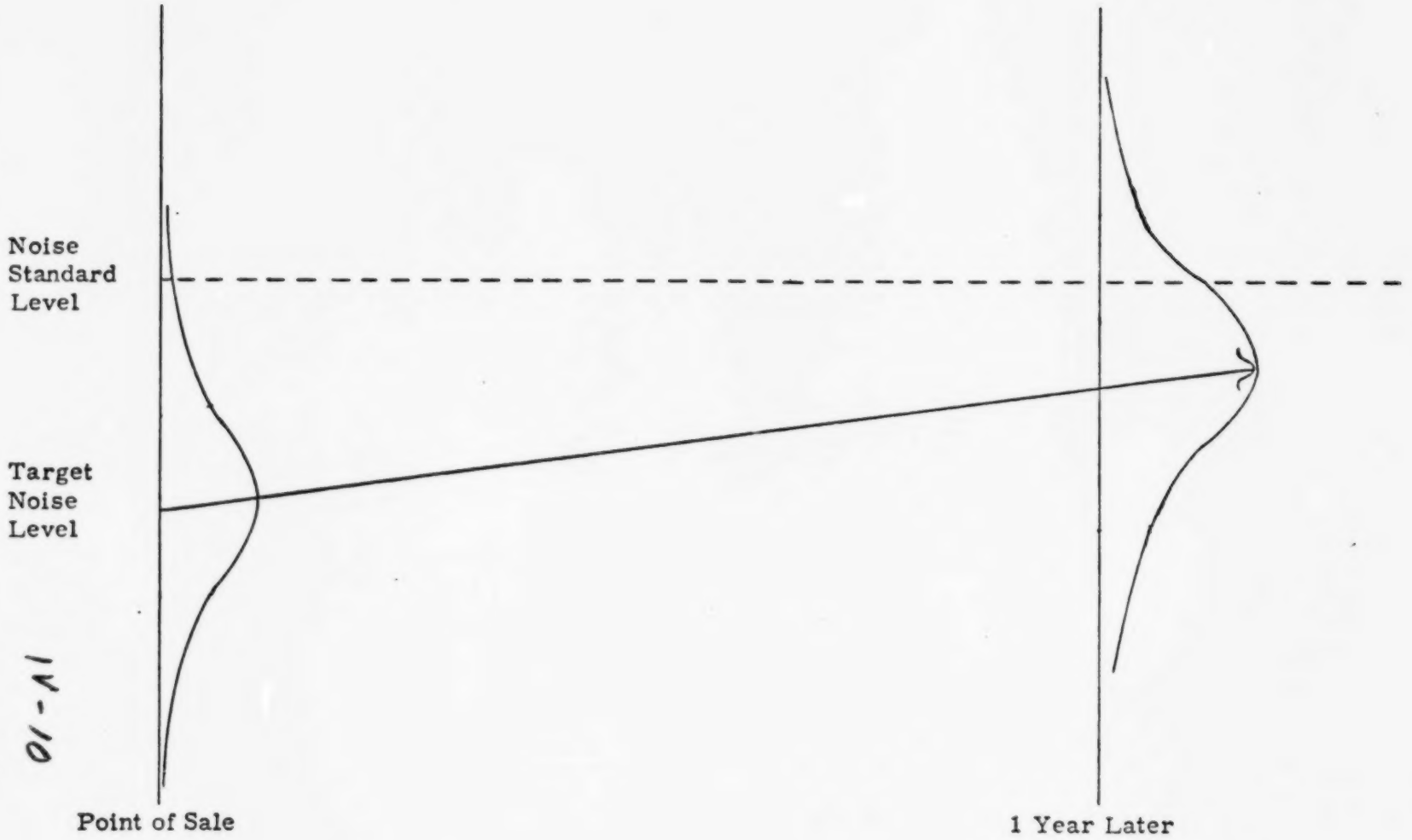

Figure IV-2. Production-degradation probability distributions.

Two examples of the usage of the above procedure for the purpose of costing the design and production costs associated with the "useful life" and warranty provisions of the regulation are described in Appendix B. The procedure can be used to test several assumptions and to indicate the range of results associated with these assumptions, and hence the degree of risk taken by EPA and the manufacturers in making decisions with incomplete information, as well as the policy trade-offs involved. Table IV-1 summarizes Example #1.

The assumptions made are that manufacturers begin with a target (average) production noise level of 74 dBA, a production standard deviation of 0.5 dBA (implying a range of $\pm$ 1.5 dBA), that the average degradation is 1 dBA over 1 year, and the standard deviation of degradation is 0.3 dBA. The assumptions appear in the first row of Table IV-1. The fifth and sixth columns give the parameters of the combined distribution. With these assumptions, there will be 9 percent non-complying equipment 1 year later. If the average degradation, however, is 1.5 dBA with a standard deviation of 0.4 dBA, the percentage of non-complying equipment rises to 27. This may be deemed excessive by EPA. It is worth noting that, in either case, with the production distribution assumed, the range of noise variation around the target is $\pm$ 1.5 dBA and therefore the maximum noise level that can be expected at the point of sale is 75.5 dBA, meaning that virtually every air compressor would pass a Selective Enforcement Audit test. Yet, because of degradation, the percentage of non-complying equipment a year later may become significant. Similar calculations will show that if manufacturers would like to reduce the percentage of non-complying equipment from 27 percent to around 9 percent by lowering their production target, they would have to aim at approximately 73.5 dBA instead of 74 dBA.

On the other hand, if EPA allowed for a 1 dBA degradation over one year the manufacturers could keep their current 74 dBA target and still have only 3 percent non-complying equipment after one year of use.

PROBABILITY DISTRIBUTION OF PRODUCTION		PROBABILITY DISTRIBUTION OF DEGRADATION AFTER 1 YEAR		PROBABILITY DISTRIBUTION OF NOISE READINGS AFTER 1 YEAR			
Mean m_1 (dBA)	St. dev. σ_1 (dBA)	Mean m_2 (dBA)	St. dev. σ_2 (dBA)	Mean m (dBA)	St. dev. σ (dBA)	REGULATION LIMIT (dBA)	PERCENT NON-COMPLYING AFTER 1 YEAR
74.0	0.5	1.0	0.3	75.0	0.77	76	9
74.0	0.5	1.5	0.4	75.5	0.81	76	27
73.5	0.5	1.5	0.4	75.0	0.81	76	9
74.0	0.5	1.5	0.4	75.5	0.81	77	3

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Table IV-1. Example #1 of cost estimation.

(Assumption about the probability distribution of sound measuring instrument error: normal with mean zero and standard deviation 0.5 dBA)

Similar calculations as above could be made for different time periods by assuming different degradation values. Currently existing data on degradation are very scanty and inadequate to produce results with any degree of confidence.

It is easy to get an estimate of costs associated with a reduction of the noise level by 0.5 dBA or any other quantity if marginal cost estimates for quieting exist. TEMPO has produced such estimates elsewhere in this report. Using the incremental cost estimates presented in Table II- , a 0.5 dBA reduction in noise from 74 to 73.5 dBA would cost the manufacturers between $0.20 and $0.40 per cfm. Note, however, that this is not the full cost which should be attributed to the "useful life" and warranty provisions of the regulations since the production target of 74 dBA is, under the assumptions made, more than adequate to comply with the noise limit at the point of sale. Therefore, it contains at least some of the costs of complying with the regulation a year later.

The results of Example #2 are summarized in Table IV-2. The figures in the first four columns represent the assumptions made. The next two figures list the parameters of the combined distribution. With these parameters, most of the air compressors (72%) will be non-complying after one year of use. If the manufacturer wishes to reduce the percentage of non-complying equipment to 10 by lowering the production target, he must lower that target by 3.2 dBA to 70.8 dBA.

The manufacturer would perhaps try to accomplish the 10 percent goal by modifying some of the other parameters as well and could be expected to choose the least costly combination within technological constraints. If we had data on what it costs to reduce each of these parameters we could point out some likely manufacturers' choices. However, the only data we have is marginal cost of reducing m_1. Using the incremental cost estimates presented in Table II- , a 3.2 dBA reduction from

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PROBABILITY DISTRIBUTION OF PRODUCTION		PROBABILITY DISTRIBUTION OF DEGRADATION AFTER 1 YEAR		PROBABILITY DISTRIBUTION OF READING AFTER 1 YEAR				
Mean m_1 (dBA)	St. dev. σ_1 (dBA)	Mean m_2 (dBA)	St. dev. σ_2 (dBA)	Mean m (dBA)	St. dev. σ (dBA)	PERCENT NON-COMPLYING AFTER 1 YEAR	PERCENT NON-COMPLYING ALLOWED AFTER 1 YEAR	ADJUSTED INITIAL TARGET (dBA)
74	1.32	3	1	77	1.73	72	10	70.8

Table IV-2. Example #2 of cost estimation.

(Assumption about the probability distribution of sound measuring instrument error: normal with mean zero and standard deviation 0.5 dBA)

74 dBA would cost between $1.50 and $2.60 per cfm (note though that the confidence of estimates for levels below 72 dBA decreases substantially).

A number of other examples were calculated and the results are given in Table IV-3. Costs for reductions in the production noise level target for the figures shown range from about $0.40 to $0.80 per dBA per cfm.

TESTING COSTS

There are two types of tests mentioned in the proposed regulations: (1) production verification test, and (2) selective enforcement audit (SEA). The production verification test is required on production prototypes of portable air compressors for every equipment category. A portable air compressor category is now defined in terms of engine type and rated capacity in cfm.

Direct costs of production verification testing include all costs directly related to the testing procedure itself and are due to such things as testing facilities, equipment, labor and materials required for testing, etc. Such costs are mainly capital costs and have been calculated by A. T. Kearney and reported in Appendix C of their report entitled "A Study to Determine the Economic Impact of Noise Emission Standards in the Construction Equipment Industry: Portable Air Compressor Report."

After the original version of the regulation was published in the Federal Register, the Air Compressor Industry complained about indirect costs imposed by the testing procedures as described in the regulation. These indirect costs were related mainly to disruptions in the production and distribution process caused by adverse weather conditions and other factors affecting testing. It is our understanding that EPA is considering changes so that no significant indirect costs will be imposed

Production Distribution		Degradation Distribution		Combined Distribution		Production Target (dBA)	
Mean m_1 (dBA)	Standard Deviation σ_1 (dBA)	Mean m_2 (dBA)	Standard Deviation σ_2 (dBA)	Mean m (dBA)	Standard Deviation σ (dBA)	Percent non-complying equipment after 1 year of use 10%*	25%*
73	0.5	1.5	0.4	74.5	0.81	73.0	73.0
73	0.5	2.0	0.6	75.0	0.98	72.8	73.0
73	1.0	1.5	0.4	74.5	1.19	73.0	73.0
73	1.0	2.0	0.6	75.0	1.27	72.4	73.0
73	1.5	1.5	0.4	74.5	1.63	72.4	73.0
73	1.5	2.0	0.6	75.0	1.69	71.8	72.9
74	0.5	1.5	0.4	75.5	0.81	73.5	74.0
74	0.5	2.0	0.6	76.0	0.98	72.8	73.3
74	1.0	1.5	0.4	75.5	1.19	73.0	73.7
74	1.0	2.0	0.6	76.0	1.27	72.4	73.2
74	1.5	1.5	0.4	75.5	1.63	72.4	73.4
74	1.5	2.0	0.6	76.0	1.69	71.8	72.9

(Assumption about the probability distribution of sound measuring instrument error: normal with mean zero and standard deviation 0.5 dBA.)

Table IV-3. Production Targets for Various Combinations of Production and Degradation Parameters Assuming Normal Distributions

* This percentage does not represent Acceptable Quality Level, but, rather the percentage of non-complying equipment which can be expected to exist after one year of use with the assumptions made.

on the manufacturers. In addition, the redefinition of the categories on which production verification testing is required has eliminated a large part of the costs the manufacturers were complaining about. Finally, the development of near-field testing procedures by the manufacturers tends to eliminate a large part of the risk from manufacturers' decisions not based on the formal test required by the regulation; e.g., the manufacturer may begin production of air compressors from a prototype after he satisfies himself that the produced equipment is complying with the regulation on the basis of a near-field test rather than awaiting the results of the formal test. EPA has not asked us to elaborate any further on the subject of testing costs.

With respect to the Selective Enforcement Audit it is our impression that EPA considers any costs associated with such tests as costs of non-compliance rather than costs of compliance. Therefore, it is not incumbent upon EPA to calculate such costs.

SECTION V

ECONOMIC IMPACTS

INTRODUCTION

The average costs of quieting and associated price increases estimated in Section II represent the immediate first order impacts of the portable air compressor manufacturing industry achieving compliance with alternative sound level standards. These estimates are based on the assumption that sufficient time is given to the industry to allow orderly adjustment to the new requirements. This section considers the possible economic impacts that may result from these cost and price increases. The analysis relies heavily upon background data presented in the ATK Report, supplemented by more recent information collected by EPA and TEMPO.

This section first considers additional impacts on the portable air compressor industry, especially on sales and employment. This is followed by a discussion of the resource costs to society and a discussion of the portion of those costs as they may show up in the accounts of the contract construction industry.

IMPACTS ON THE PORTABLE AIR COMPRESSOR INDUSTRY

Impact on Industry Sales

AT Kearney assumed that a price elasticity of -0.35 was appropriate in estimating the demand response to price increases of less than

20 percent. TEMPO has no basis for making a different assumption about the price elasticity of demand for portable air compressors.*

The decrease in sales resulting from the price increases associated with alternative SPL production targets is given in Table V-1, under the assumption of an elasticity of -0.35. This table assumes the price increases presented in Table II-1 (Section II, above).

Table V-2 transforms the results of Table V-1 into the sales impact of the eight regulatory options given earlier in Table I-1. Due to insufficient data, no distinction is made among options that differ only in terms of the time of the results given in Section III. However, options with a compliance time of 12 months may result in significant disruptions in the markets for several compressor product lines, due to the large number of non-complying compressor models. Manufacturers trying to avoid non-compliance in these product lines with accelerated quieting programs are likely to experience significant costs not reflected in the price impact estimates given here.

Decreased industry sales for all options range between three and five percent. The worst case estimate for an SPL target of 73 dBA (corresponding to a 76 dBA standard and 3 dBA tolerance) is the only exception, with a value of 6.1 percent. In most cases, the largest sales impact falls on the diesel-driven compressors with more than 250 cfm capacity. These impacts are equivalent to one to two years of sales growth at the rates experienced by the industry from 1967 to 1972, but are less than

* The response to price increases in this discussion is considered under the assumption that the prices of substitutes remain constant. To the extent that substitutes for portable air compressors experience comparable price increases, e.g., due to other government regulations, the demand response to increasing air compressor prices will be dampened.

Table V-1. Estimated decrease in sales, total and by major engine/capacity class, assuming a price elasticity of demand of -0.35.

SPL Target	Percent Decrease in Sales			
	Gasoline	Diesel (≤250 cfm)	Diesel (>250 cfm)	All Models
Mid-Estimate				
76 dBA	3.0%	2.4%	4.0%	3.5%
75	3.6	2.9	4.2	3.9
74	4.2	3.4	4.6	4.3
73	5.0	3.8	4.9	4.8
Worst Case				
75 dBA	3.8	2.9	5.7	4.8
73	5.5	4.0	6.9	6.1

Table V-2. Mid-estimates of decreased sales associated with EPA regulatory options.

Regulatory Option	Air Flow Capacity (cfm)	Sound Pressure Level (dBA at 7 meters)	Time to Compliance (months)	Percent Price Increase (mid-estimate)		Percent Decrease In Sales (elasticity of -0.35)	
				2 dBA Tolerance	3 dBA Tolerance	2 dBA Tolerance	3 dBA Tolerance
1	All	76	12	a	a	a	a
2	All	76	18	12.3	13.6	4.3	4.8
3	All	78	18	10.0	11.1	3.5	3.9
4	Under 251 Above 250	76 76	18 24	- 12.3	- 13.6	- 4.3	- 4.8
5	Under 251 Above 250	76 76	12 24	b	b	b	b
6	Under 251 Above 250	76 78	12 18	c	c	c	c
7	Under 251 Above 250	76 76	12 18	b	b	b	b
8	Under 251 Above 250	76 78	18 24	- 11.2	- 12.5	- 4.0	- 4.3

[a]May not be adequate time for orderly adjustment.
[b]Same as Option 4, if time for orderly adjustment.
[c]Same as Option 8, if time for orderly adjustment.

one-fifth of the industry sales growth from 1972 to 1973.* (Sales data for 1974 are not available.)

Impact on Industry Employment

Decreased industry sales will tend to lower employment in the industry from what it would have been in the absence of the regulations. However, the labor required per manufactured compressor will tend to increase, due to the quieting requirements. Data are not available to determine the net effect of these two counter-acting forces.

A portion of any net decrease in employment could be accomplished by normal attrition. It has been common in recent years for between two and three percent of the labor force in all manufacturing to leave their job voluntarily.** Data on labor turnover in the portable air compressor industry are not available.

Based on the estimated impacts on industry sales, industry-wide employment impacts of any of the regulatory options would not appear severe, provided sufficient compliance time is allowed.

SOCIETAL RESOURCE COSTS

The total resource cost of achieving lower SPL's to become compliant with any of the regulatory options is composed of many parts. Additional resources --- labor, materials, and capital — must be used in the production of the quieter compressors. To the extent that the users of portable air compressors go to substitute technologies (e.g., electric and hydraulic equipment) or make other adjustments to avoid

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* See Appendix C, Table C-1.

** Manpower Report of the President, April 1975, p. 291.

purchasing the higher priced compressors, they are adopting alternative methods of production that presumably would have been more costly than the lower priced unquieted compressors. Users are therefore avoiding the cost of higher priced compressors by incurring the cost of previously less favored methods of production. And to the extent that new air compressor sales are reduced, labor in the industry may be unemployed while moving from their present employment to alternatives --- a third type of resource cost.

Data are not available to assess the value of each of these components of the resource costs of the regulatory options and the distribution of these costs among the different segments of society (e.g., labor, the construction industry, the purchasers of new construction, and the compressor manufacturing industry). As an alternative, an assessment has been made under the assumption that the only societal adjustment to the new regulations is to re-allocate the required resources to the air compressor industry to produce quieter equipment. This assumption implies that there is no decrease in industry sales in response to higher prices and, consequently, no associated unemployment. The assumption is also made that the increase in list price includes a normal profit or return to capital resources utilized in the quieting of compressors.

With these assumptions, the total resource cost of a regulatory option may be approximated by the dollar value increase in compressor sales under the assumption that prices increase by the percentages computed in Section II and that unit sales are not changed in response to the higher prices. This assessment makes no statement as to the manner in which these costs are distributed among the different segments of society.

Using these assumptions, the value of resource costs were calculated for the first year of full compliance of each regulatory option with a compliance time of 18 months or longer for all classes of portable air compressors. The base year sales used in the calculation is for the 12

months beginning on the date on which all new compressors (regardless of capacity) are covered by the regulation, assuming the regulation is promulgated in July 1975. Base year unit sales are those reported in the ATK Report. Base prices were computed from 1975 compressor price data collected by EPA. (See Table C-2 in Appendix C.)

The results of the calculations are presented in Table V-3. These calculations used mid-estimate price increases, and produce estimates of the value of the resource cost of the regulatory options ranging from $20 to $28 million. The use of worst-case price estimates would have resulted in resource costs ranging from one-third (for option 8) to one-half (for option 4) higher.

USER COSTS

If a user, e.g., a construction contractor, purchases a new quieter and more expensive portable air compressor, the higher price paid represents an increase in his investment expenditures. The book value of his equipment (carried at cost) will be increased by the amount of the higher price. This amount will be depreciated over the accounting life* of the equipment in order to allocate the cost of equipment over the revenue received through the operation of the equipment.

If the user borrows the funds required to finance the purchase, he bears an additional interest cost attributable to the higher purchase price of the equipment. If he uses equity financing, he forgoes the opportunity of investing the additional funds in other income generating activities and thus incurs an opportunity cost just as real as the interest cost of debt financing. In either case, the user bears an increased cost of financing the equipment purchase that may be associated with the higher price.

* Accounting life and true useful life need not coincide.

Table V-3. Mid-estimates of the first year societal resource costs of the regulatory options.

Regulatory Option	Air Flow Capacity (cfm)	Sound Pressure Level (dBA at 7 meters)	Time to Compliance (months)	First Year Societal Resource Cost ($ millions)	
				2 dBA Tolerance	3 dBA Tolerance
1	All	76	12	a	a
2	All	76	18	25.0	27.6
3	All	78	18	20.3	22.6
4	Under 251 Above 250	76 76	18 24	- 25.4	- 27.9
5	Under 251 Above 250	76 76	12 24	b	b
6	Under 251 Above 250	76 78	12 18	c	c
7	Under 251 Above 250	76 76	12 18	b	b
8	Under 251 Above 250	76 78	18 24	- 23.4	- 25.7

[a]May not be adequate time for orderly adjustment.
[b]Same as Option 4, if time for orderly adjustment.
[c]Same as Option 8, if time for orderly adjustment.

Following the assumptions used by A. T. Kearney, it is assumed depreciation is 10 percent of the original cost of the equipment and that 10 percent of the purchase price gives an appropriate cost of financing. Using these assumptions, a user will record 20 percent of the increased purchase price to his operating costs each year. Following A. T. Kearney, it is also assumed that all other costs incurred by a user as a result of the noise regulations are negligible.

The first full year of compliance the increased cost to appear in the income statements of the users of the new quieted equipment is, with the assumptions given above, equal to 20 percent of the resource costs given in Table V-3. These first year user costs are presented in Table V-4, and range between $4 and $6 million.

To calculate the corresponding user cost for the first year of a 100 percent quieted portable air compressor population, the following assumptions were made:

1. All new quieted equipment survives at least 10 years.

2. No existing unquieted equipment survives more than 10 years.

3. Portable air compressor sales grow at a constant rate over the first 10 years of the regulation.

Two sets of growth rates are used. The first set is the average annual rate of unit sales growth experienced from 1967 through 1972 (i.e., 2.8 percent for small compressors and 3.6 percent for large compressors) and the second rate of growth is that experienced from 1967 through 1973 (i.e., 6.0 percent for small compressors and 7.0 percent for large compressors). (See Table C-1, Appendix C.)

Table V-4. First year user costs.

Regulatory Option	Air Flow Capacity (cfm)	Sound Pressure Level (dBA at 7 meters)	Time to Compliance (months)	User Cost, First Year ($ millions)	
				2 dBA Tolerance	3 dBA Tolerance
1	All	76	12	a	a
2	All	76	18	5.0	5.5
3	All	78	18	4.1	4.5
4	Under 251 Above 250	76 76	18 24	- 5.1	- 5.6
5	Under 251 Above 250	76 76	12 24	b	b
6	Under 251 Above 250	76 78	12 18	c	c
7	Under 251 Above 250	76 76	12 18	b	b
8	Under 251 Above 250	76 78	18 24	- 4.7	- 5.1

[a]May not be adequate time for orderly adjustment.
[b]Same as Option 4, if time for orderly adjustment.
[c]Same as Option 8, if time for orderly adjustment.

These growth rates result in 100 percent quieted populations at the end of ten years equal to 11.61 and 13.56 times the number of new compressors purchased during the first full year of compliance. These 100 percent quieted user costs are presented in Table V-5, with values ranging between $48 and $76 million.

These values are quite small relative to the total value of construction, corresponding to the relatively small size of the portable air compressor industry. The 100 percent quieted user cost of $76 million, for example, is only 0.06 percent of the $135 billion value of new construction in 1973.

This implies that any regulation that does not cause significant disruptions in the supply of portable air compressors will probably have relatively little aggregate impact outside the portable air compressor industry.

Table V-5. 100 percent quieted population user costs.

Regulatory Option	Air Flow Capacity (cfm)	Sound Pressure Level (dBA at 7 meters)	Time to Compliance (months)	User Cost, 100% Quieted Population ($ millions)			
				1967 - 1972 Growth Rate[d]		1967 - 1973 Growth Rate[e]	
				2 dBA Tolerance	3 dBA Tolerance	2 dBA Tolerance	3 dBA Tolerance
1	All	76	12	a	a	a	a
2	All	76	18	58.1	63.9	67.8	74.6
3	All	78	18	47.6	52.2	55.6	61.0
4	Under 251 Above 250	76 76	18 24	- 59.0	- 65.0	- 68.9	- 75.9
5	Under 251 Above 250	76 76	12 24	b	b	b	b
6	Under 251 Above 250	76 78	12 18	c	c	c	c
7	Under 251 Above 250	76 76	12 18	b	b	b	b
8	Under 251 Above 250	76 78	18 24	- 54.6	- 59.2	- 63.7	- 69.2

[a] May not be adequate time for orderly adjustment.
[b] Same as Option 4, if time for orderly adjustment.
[c] Same as Option 8, if time for orderly adjustment.
[d] 2.8 percent for small compressors and 3.6 percent for large. See Appendix Table C-1.
[e] 6.0 percent for small compressors and 7.0 percent for large. See Appendix Table C-1.

APPENDIX A

JUSTIFICATION OF THE USE OF MATCHED PAIRS

TEMPO's treatment of the list price sound level data differed from BBN's treatment in several important respects. In particular, BBN used price/sound level data on both matched and unmatched portable air compressor models. TEMPO worked only with matched pairs of portable air compressors.

To understand the reason for using only matched pairs of compressors, standard and quieted versions of the same basic model, consider the following hypothetical example. Assume that the data consist of only four models of air compressors, each with an air flow capacity of 365 cfm. Prices and SPL's are given below:

Model	Price	SPL
1	$40/cfm	90 dBA
2	50	90
3	50	75
4	62	75

Assume also that model 3 is the quieted version of model 1 and model 4 is a quieted version of model 2. Using these matched pairs, a reasonable estimate of the cost of quieting from 90 to 75 dBA is $11.00, the average of price differentials between the standard and quiet version of each pair.

Now assume that the price and sound level of an additional compressor model are known. There is no way that this unmatched sample point can improve the estimate (i.e., of $11.00) of the cost of quieting the 365 cfm compressors from 90 to 75 dBA, since there is

mation as to what it would cost to quiet that particular model. ng the BBN procedure of using unmatched models, however, ence of the new sample point will change the estimated cost ng. Assume, for example, that the new model has a price of SPL of 90 dBA. The average price of the "standard" models $13.33, down from $45.00. The average price of the "quieted" remains at $56.00. Inclusion of the unmatched model could re- in increase in the estimated cost of quieting from $11.00 to (Similarly, if the price of the new model were higher than ious average price of the standard models, the estimated cost ing would be reduced.)

e of "Noise" Distorting Factors
rice Data

e value of using only matched pairs can be considered from perspective. Many factors in addition to sound level affect the f the compressors in each of the broad capacity classes of air ssors. These additional factors include:

1. The difference between list price and actual transaction price, i.e., the discount from list price.

2. Differences in the air flow capacity of the models within a broad capacity class, e.g., a range from 325 cfm to 2000 cfm in the large diesel class. Price per cfm generally decreases with increasing air flow capacity.

3. Differences in the quality of the different models and the nature of the field service that accompanies the purchase of a new air compressor.

4. Differences in the competitive position of specific manufacturers and product lines.

The importance of each of these factors may vary substantially from manufacturer to manufacturer and from model to model.

The estimation procedure should attempt to minimize the influence of these extraneous factors on the estimated cost of quieting. The BBN procedure does not address the problem of extracting the influence of these factors from the estimates while the TEMPO procedures address the problem in two ways. First, by using only matched pairs in the analysis these factors influence the estimates only to the extent they affect the average price differential between the standard and quieted versions of a matched pair. Second, the average costs of quieting are computed from weighted averages of the costs of quieting for narrow capacity ranges. The weights used depend only upon the relative importance of the different capacity classes in the sale of compressors, and are independent of the sample size of each capacity class. The weighting procedure reduces the influence of a capacity class that is particularly cheap (or expensive) to quiet and has, therefore, an unusually large (or small) representation in the sample of matched pairs.

APPENDIX B

COMBINING PROBABILITY DISTRIBUTIONS

The process of combining probability distributions is accomplished on the basis of a theorem which states that the probability distribution of the sum of random variables has a mean which is the sum of the means of the random variables and a standard deviation which is the square root of the sum of the squares of the standard deviations.* For example, if

$$x = x_1 + x_2$$

and x_1 has mean m_1 and a standard deviation σ_1; and x_2 has mean m_2 and a standard deviation σ_2, then the mean m of x is

$$m = m_1 + m_2$$

and the standard deviation σ of x is

$$\sigma = \sqrt{\sigma_1^2 + \sigma_2^2}$$

Thus, if a portable air compressor has a production distribution with a mean

$$m_1 = 74 \text{ dBA},$$

* The latter holds true if the random variables are independent. This is an assumption we are making here.

and a standard deviation

$$\sigma_1 = 1 \text{ dBA};$$

and the acoustical degradation over 1 year has a mean

$$m_2 = 2 \text{ dBA}$$

and a standard deviation

$$\sigma_2 = 0.5 \text{ dBA},$$

then the combined distribution of noise level has a mean

$$m = m_1 + m_2 = 74 + 2 = 76 \text{ dBA}$$

and a standard deviation

$$\sigma = \sqrt{\sigma_1^2 + \sigma_2^2} = \sqrt{1^2 + (0.5)^2} = \sqrt{1.25} = 1.12 \text{ dBA}.$$

Another important point concerns the type of distributions involved. Figure IV-2 portrays normal distributions; however, it is perhaps more likely that the distributions are asymmetrical, and in particular skewed downward so that the range of values lower than the mean is generally shorter than the range of values higher than the mean. This can be explained by the fact that it is more difficult to produce portable air compressors which are quieter than the target level than to produce portable air compressors which are noisier than the target level. It is not known what the type of asymmetrical distributions associated with the production

process of portable air compressors is. Besides, the type as well as the degree of skewness is likely to vary from manufacturer to manufacturer. The only thing that can be said is that with a skewed distribution upward deviations from the mean are generally larger and more likely than in the symmetrical case. To each combined distribution derived as described above, the error distribution of the sound measuring instrument can be overlaid to get a distribution of actual noise level readings.

EXAMPLE #1

Let us make the following assumptions:

The production distribution of a portable air compressor is normal with mean m_1 = 74 dBA and standard deviation σ_1 = 0.5 dBA.* This distribution includes the measuring instrument error. The degradation distribution after, say, one year is normal with mean m_2 = 1 dBA and standard deviation σ_2 = 0.3 dBA. We are also taking explicitly into account the measuring error with a normal distribution having mean m_3, of zero dBA and a standard deviation σ_3 of 0.5dBA.**

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* The range of values around the mean can be approximately estimated in the case of the normal distribution by multiplying the standard deviation by 6, i.e., if the standard deviation is 1 dBA the range around the mean is 6 dBA or $\pm$ 3 dBA.

**Since we are considering degradation explicitly we also have to consider the error distribution explicitly and synthesize the combined distribution from its three constituent distributions: the production, the degradation and the error distributions.

With these assumptions the combined distribution has a mean and a standard deviation:

$$m = 74 + 1 + 0 = 75 \text{ dBA}$$

$$\sigma = \sqrt{(0.5)^2 + (0.3)^2 + (0.5)^2} = \sqrt{0.59} = 0.77 \text{ dBA}$$

We are interested in determining the probability that a portable air compressor will exceed 76 dBA after one year of use, or, put otherwise, the fraction of the in-use population of air compressors sold a year earlier which exceeds a noise level of 76 dBA. This is the area under the combined distribution to the right of 76 dBA. We can find this from standard normal tables by making the transformation:

$$t = \frac{76 - m}{\sigma} = \frac{76 - 75}{0.77} = 1.3$$

This value of t corresponds roughly to the 91st percentile of the standard normal which means that the area to the right of 76 dBA is 9 percent of the total area. Therefore, under the assumptions made, the percentage of non-complying equipment after one year of use is 9 percent. These assumptions and results, as well as the results below, are shown on Table IV-1.

Now suppose that the degradation distribution was erroneous and that actually the mean m_2 is 1.5 dBA and the standard deviation σ_2 is 0.4 dBA, then

$$m = 74 + 1.5 + 0 = 75.5 \text{ dBA}$$

$$\sigma = \sqrt{(0.5)^2 + (0.4)^2 + (0.5)^2} = \sqrt{0.66} = 0.812 \text{ dBA}$$

$$t = \frac{76 - 75.5}{0.812} = 0.62 \text{ dBA}$$

and the percentage of non-complying equipment increases to 27 percent.

EXAMPLE #2

Let us make the following assumptions as to the values of the parameters defined in the first example:

$$m_1 = 74 \text{ dBA}$$

$$\sigma_1 = 1.32 \text{ dBA}$$

$$m_2 = 3 \text{ dBA}$$

$$\sigma_2 = 1 \text{ dBA}$$

$$m_3 = 0 \text{ dBA}$$

$$\sigma_3 = 0.5 \text{ dBA}$$

With this set of assumptions the percentage of non-complying equipment at the point of sale is 10 percent, which is exactly what is currently required in order to pass the Selective Enforcement Audit test. So any changes made in the production process would be made in order to comply with the "useful life" and warranty provisions of the regulations. The combined distribution has the following values for its parameters:

$$m = 74 + 3 + 0 = 77 \text{ dBA}$$

$$\sigma = \sqrt{(1.32)^2 + 1^2 + (0.5)^2} = \sqrt{2.99} = 1.73 \text{ dBA}$$

To find the percentage of non-complying equipment we calculate the quantity

$$t = \frac{76 - 77}{1.73} = -0.58$$

For this value of t the area of the standard normal to the right of 76 is 0.72. Therefore, the percentage of non-complying equipment is 72.

Let us suppose that the manufacturer wants to achieve a goal of no more than 10 percent non-complying equipment after one year in use. Statistically, this can be achieved by lowering the mean of the combined distribution, or by lowering the mean and reducing the standard deviation σ. (Merely reducing the standard deviation will not achieve the desired result because the mean exceeds 76 dBA.) This means that any or all of the m_1, σ_1, m_2, σ_2, would have to be reduced. The 90th percentile of the combined distribution is 79.2 dBA. This means that if the manufacturer chooses to meet the 10 percent goal by simply lowering the mean m_1 of the production distribution, he would have to lower that mean by 3.2 dBA (79.2-76) to 70.8 dBA. (These results are shown in Table IV-2.)

APPENDIX C
SUPPLEMENTARY DATA

Table C-1. Unit sales of portable air compressors, 1967-1973.

Year	Rated Air Flow Capacity		Total
	Below 251	Above 251	
1967	8,313	1,656	9,969
1968	8,156	1,563	9,719
1969	9,586	1,691	11,277
1970	9,233	1,740	10,973
1971	8,138	1,763	9,901
1972	10,183	1,971	12,154
1973	13,286	2,697	15,983
Annual Growth Rate:[a]			
1967-1972	2.8%	3.6%	2.9%
1967-1973	6.0	7.0	6.2

[a]Growth rates determined by a least squares estimation of the function

$$S_t = Ae^{rt},$$

where S is unit sales in year t, A is the regression value of sales in 1967, r is the estimated annual rate of growth, and e is the constant 2.71828.

Source: ATK Report and Department of Commerce.

Table C-2a. Calculation of standard portable air compressor average current list prices.

Power Source Type and Air Flow Capacity of Predominant Units	Number In Class	Weights	Average List Price
85 - Gasoline	11	0.273	$ 5,005.36
100 - Gasoline	7	0.117	5,168.57
125 - Gasoline	12	0.153	6,696.08
160 - Gasoline	23	0.305	7,196.17
185 - Gasoline	18	0.153	8,666.17
Weighted Average			$ 6,516.44
125 - Diesel	0	0.278	$ ———
160 - Diesel	19	0.323	9,087.68
185 - Diesel	13	0.323	10,014.15
250 - Diesel	18	0.076	17,269.94
Weighted Average			$10,363.44
365 - Diesel	19	0.204	$23,668.00
600 - Diesel	17	0.278	34,360.76
750 - Diesel	24	0.278	44,457.67
900 - Diesel	11	0.084	51,352.00
1050 - Diesel	9	0.060	60,433.78
1200 - Diesel	16	0.072	68,042.50
1600 - Diesel	6	0.017	83,952.83
1750 - Diesel	4	0.007	91,625.00
Weighted Average			$41,646.18

Table C-2b. Calculation of quieted portable air compressor average current list prices.

Power Source Type and Air Flow Capacity of Predominant Units	Number in Class	Weights	Average List Price
85 - Gasoline	8	0.273	$ 5,793.00
100 - Gasoline	7	0.117	5,729.29
125 - Gasoline	9	0.153	7,508.67
160 - Gasoline	16	0.305	7,846.63
185 - Gasoline	13	0.153	10,086.46
Weighted Average			$ 7,337.09
125 - Diesel	0	0.278	$ ————
160 - Diesel	14	0.323	9,394.07
185 - Diesel	8	0.323	10,240.63
250 - Diesel	13	0.076	19,123.15
Weighted Average			$ 10,796.91
365 - Diesel	8	0.204	$ 28,840.63
600 - Diesel	7	0.278	38,162.86
750 - Diesel	15	0.278	51,892.60
900 - Diesel	3	0.084	63,530.00
1050 - Diesel	3	0.060	68,114.67
1200 - Diesel	10	0.072	79,188.20
1600 - Diesel	2	0.017	93,395.00
1750 - Diesel	2	0.007	109,650.00
Weighted Average			$ 48,399.12